WCER Working Paper No. 2006-3
April 2006

Boolean Classes and Qualitative Inquiry

Mitchell J. Nathan
Department of Educational Psychology/
Wisconsin Center for Education Research
University of Wisconsin–Madison
mnathan@wisc.edu

Kristi Jackson
Department of Educational Foundations, Policy, and Practice
University of Colorado–Boulder/
Qualitative Education & Research, Inc.
kjackson@queri.org

WCER
Wisconsin Center for Education Research
School of Education • University of Wisconsin–Madison • http://www.wcer.wisc.edu/

Copyright © 2006 by Mitchell J. Nathan and Kristi Jackson
All rights reserved.

Readers may make verbatim copies of this document for noncommercial purposes by any means, provided that the above copyright notice appears on all copies.

WCER working papers are available on the Internet at http://www.wcer.wisc.edu/publications/workingPapers/index.php. Recommended citation:

Nathan, M. J., & Jackson, K. (2006). *Boolean classes and qualitative inquiry* (WCER Working Paper No. 2006-3). Madison: University of Wisconsin–Madison, Wisconsin Center for Education Research. Retrieved [e.g., May 15, 2006,] from http://www.wcer.wisc.edu/publications/workingPapers/papers.php

The research reported in this paper was supported by the Wisconsin Center for Education Research, School of Education, University of Wisconsin–Madison. Any opinions, findings, or conclusions expressed in this paper are those of the authors and do not necessarily reflect the views of the funding agencies, WCER, or cooperating institutions.

Boolean Classes and Qualitative Inquiry

Mitchell J. Nathan and Kristi Jackson

Boolean classes (BCs) are part of a system of combination developed by the self-taught mathematician George Boole (1815–1864). The Boolean system uses algebraic notation to describe the relationships between groups (classes) and their members, using the operations AND, OR, NOT, and Exclusive-OR (XOR; e.g., You can win what is behind *either* Curtain No. 1 or Curtain No. 2, but not both). The prominent role of Boolean classes and operators within qualitative data analysis software (QDAS) packages is seen by some social scientists as "go[ing] against the purpose and value of qualitative research" (Roberts & Wilson, 2002, ¶ 44), partly because these software packages are "based on a positivistic orientation to the social and natural worlds" (¶ 22). The emphasis on coding and retrieval (Coffey, Holbrook, & Atkinson, 1996) in qualitative data analysis is viewed as fostering a more homogeneous approach to qualitative data than exists in the qualitative research world and therefore as undermining qualitative methodology as a viable, non-positivistic form of inquiry. Such claims rely on an assumed connection between positivism, mathematics, and Boolean logic and view Boolean logic as a somewhat pedantic and uniform approach. Critics making such claims assume that Boolean logic is an outgrowth of mathematics and that the standardization and classification of mathematics drive a logic that is far too simplistic and positivistic to foster a rich analysis of qualitative data.

We contend that it is a misconception to view BCs as *derived from* mathematics and capable only of implementing a positivistic approach to data analysis. Drawing on work by Lakoff and Johnson (1980, 1999) and Lakoff and Núñez (2000; Núñez, 2000), we argue that BCs are more precisely regarded as *conceptual metaphors* of some of the embodied ways that humans naturally perceive and act upon everyday things in the world, such as objects, categories, and containers. By *embodied ways*, we mean approaches that are rooted in our actions and perceptions, even when we are considering abstract entities. BCs are metaphoric relations in that they stipulate a unidirectional, cross-domain mapping that preserves the inferential structure of the source domain (objects) when it is applied to the target domain (concepts). Rather than expressing some transcendent notion of a universal logic of formal entities (e.g., sets) that supersedes our knowable experience, BCs can be conceptualized as metaphors for apprehending and manipulating concepts and categories in the same way we apprehend and manipulate objects and containers. As Núñez (2000) noted, "conceptual metaphors are not mere figures of speech," nor "pedagogical tools," but hypothesized "cognitive mechanisms" that support abstract inference in the new domain of inquiry (p. 10). In this view, the meaning and behavior of BCs are actually grounded in and constrained by bodily and neural-perceptual processes. These include processes for how we perceive object boundaries (e.g., Hubel & Wiesel, 1968) and groups (e.g., subitizing), and how we tend to perceive and organize collections. The Gestalt laws of *Prägnanz* or perceptual organization (i.e., proximity, similarity, continuity, symmetry, and closure; Arnheim, 1974; see also Figure 1) illustrate these principles and constraints. In this paper, we explore the current debate on the role and impact of BCs in QDAS packages and discuss the nature of BCs from the perspective of embodiment theory. We go on to explore implications of the embodiment view of BCs for education research and for the current qualitative/quantitative paradigm wars in an attempt to promote more effective ways of sorting

through the real differences and similarities between quantitative and qualitative inquiry methods.

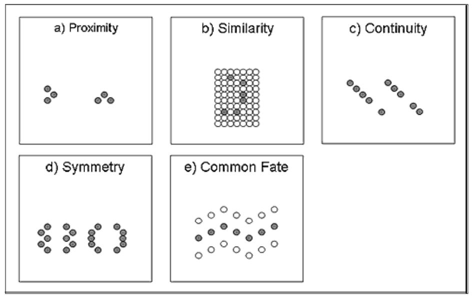

Figure 1. Gestalt principles of perceptual organization that mediate how we form collections: The laws of proximity, similarity, continuity, symmetry and common fate.

The Debate Over Boolean Classes in Qualitative Research

In 1996, Coffey, Holbrook, and Atkinson published an article that critiqued QDAS as a tool that fostered a uniform approach to qualitative data and ignored a diversity of representational devices. Lonkila (1995) also stated that QDAS overemphasized the coding of qualitative data, given the thoughtful, interpretive work that is necessarily part of qualitative analysis. Lee and Fielding (1996) challenged this view with their own studies showing that software users took many different approaches to the coded data *after* retrieval. Far from being an orthodox, monolithic shaper of analysis, computer programs made some procedures possible that were impractical to conduct prior to the emergence of QDAS. Lee and Fielding concluded that coding and data reduction may be a *necessary* precursor to other interpretive strategies.

Since these original arguments were made, the capabilities of software packages such as NVivo, MAXqda, ATLAS.ti, and Transana have expanded. Nonetheless, there seems to be little overt discussion about the implications of the Boolean debate for coding practices or for bridging quantitative and qualitative research methods. Yet, QDAS bias and searches based in Boolean logic clearly remain issues beneath much of the discourse on the use of software to analyze qualitative data. In his *Dictionary of Qualitative Inquiry*, Schwandt (2001) noted that every tool has an ideological bias, and so, too, must QDAS. He asserted that awareness of this bias may be more often expressed by developers and frequent users of QDAS, but he did not provide examples of the bias or guidance on where to find such a discussion. In our view, this omission is likely attributable to the paucity of substantive discussion regarding QDAS bias in the published literature.

Creswell (2003) described the terms currently used by QDAS programs to describe search features based in Boolean logic (*query tools*, *search procedures*, *hypothesis testers*, *index search operators*, *logic machines*). Creswell and Maietta (2002) provided a framework for comparing software tools based on eight types of features, including concept combination tools such as those listed above (searches based in Boolean logic and dependent on some form of coding) and conceptual maps (which draw on tools that support creation of relations to support a network-level understanding). This categorization of tools parallels comparisons in earlier

debates (Coffey at al., 1996; Barry, 1998) that placed some packages in the more sequential and linear (hierarchical coding) camp and others in the more complex and interconnected (conceptual mapping and hypertext links) camp. Nonetheless, Creswell and Maietta provided no discussion of the relationship of these tools to fundamental cognitive processes. Such a discussion would contribute to a deeper understanding of when to use the various tools—including Boolean searches—to further a rich analysis of qualitative data. It is to this discussion that we now turn.

Embodiment View: Where Classes Come From

The *embodiment view* (e.g., Clark, 1999; Dreyfus, 1992; Heiddegger, 1927/1962; Merleau-Ponty, 1945/1962)—as well as related fields such as *embodied cognition* (e.g., deVega, Glenberg, & Graesser, in press; Glenberg, 1997; Lakoff & Johnson, 1980, 1999) and *ecological psychology* (Gibson, 1979)—frames the structure and development of human behavior and human thinking in terms of the central role of the environment and the sensorimotor processes that mediate environmental interactions. One key idea is that interactions with *physical* entities become appropriated as a means to describe interactions with *conceptual* entities. In their book, *Where Mathematics Comes From*, Lakoff and Núñez (2000) argued that the formal notion of *class,* as articulated by Boole in the 1840s and 1850s, draws on our everyday perceptions of and actions on collections of objects and containers. Containers bound regions of space that visually and tactilely determine what is and is not contained (see Figure 2).[1] Reasoning with and about containers depends on a rich *container schema*—that is, a general mental construct for thinking about how to hold and store things that humans develop through their many and varied interactions with the world (Lakoff & Johnson, 1980). It is by drawing on schemas like the container schema that we generalize from our sensory experiences to new entities (e.g., using relational concepts such as *on, in, with,* and so forth).

Conceptual metaphor is the mechanism by which we apply sensorimotor constructs like the container schema more broadly (Lakoff & Johnson, 1980). Metaphor (Bowdle & Gentner, 2005) allows us "to reason about one kind of thing as if it were another" (Lakoff & Núñez, 2000, p. 6). It is a powerful, general means by which we can extend our experience and understanding of the behavior and perceptions of familiar objects to entities with very different properties. Embodiment theory views metaphor not merely as a figure of speech, but as a basic neural mechanism that allows us to use the inferential structure of one conceptual domain (say, the aggregation of similar objects) to reason about another (say, the aggregation of similar ideas). The composition of our container schema is determined by our evolutionary, neural, perceptual, historical, and cultural makeup. That is, it is a product of our experiences and the norms of interaction of the people and artifacts with whom we interact, while also highly influenced by the ways our bodies allow us to move within, manipulate, and perceive the world. These influences determine both what we recognize as containers and how we interact with them through actions and discourse.

[1] Although many alternative psychological models have been developed for conceptualizing groups and categories—e.g., fuzzy sets, probabilistic membership, prototypes—the container metaphor has historically enjoyed great prominence due to its simplicity as a first-order account of human cognition (e.g., Bruner, Goodnow, & Austin, 1956).

Through conceptual metaphor, we readily apply our notion of a container to many other entities. Speakers will spontaneously use a gesture signaling a container when discussing something as abstract and ephemeral as a genre of film they are asked about (McNeill, 1992). For example, in one interview, a speaker responded, "It was a Sylvester and Tweety cartoon," making a gesture indicating he was "opening up" an invisible container before him to discuss the specific events that unfolded as though they were its contents. In spoken language, we regularly use container metaphors to describe nonphysical entities, such as personal beliefs, intellectual development, and organizational structure (e.g., "Ann is *in* the Educational Psychology Department"). Concepts are, of course, not objects. They lack mass (though we talk about *weighty ideas*), matter (though they may have or lack *substance*), and form (though they can be *slippery* or *overarching*). Yet, we naturally appropriate the perceptual, motoric, and cognitive processes that we have developed from our experiences with objects for our conceptual apparatus of classes and members. In the language of embodiment theory, our preexisting notions of objects and containers serve as *grounding metaphors* for our new notions of concepts and theories. We talk about, think about, and even make inferences about conceptual entities in a manner that is in keeping with our thoughts about objects.

Consider the arrangement depicted in Figure 2 (Lakoff & Núñez, 2000). There is much we can say about the visual/physical arrangement of objects *x* and *y* and containers *A* and *B*: If object *x* is in container *A*, it is also in *B*; if object *y* is outside container *B*, it is also outside *A*; and so on. Indeed, the four basic laws of logical inference, reproduced for convenience in Table 1, can be seen in Figure 2. Far from exhibiting a transcendent quality of universal truth, these laws emerge simply as abstractions from our everyday engagement with objects and containers. In this way, BCs are simply metaphorical extensions of everyday classes. The representational power of BCs, then, follows from the properties (i.e., entailments) that they share with the behavior, affordances, and constraints of collections of physical objects.

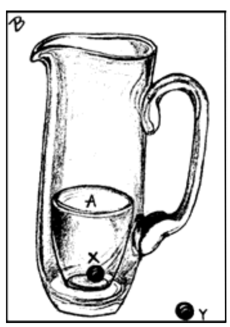

Figure 2. An illustration of how object-container relations parallel those found in Boolean logic statements like those in Table 1 (from Lakoff & Núñez, 2000).

As evidence that the container metaphor extends beyond mere speech, inferences that may naturally follow physical containers and objects, such as those depicted in Table 1, can also be imputed to conceptual entities. Thus, following the earlier example of organizational structure ("Ann is *in* the Educational Psychology Department"), if the Educational Psychology Department is *in* the School of Education, one can conclude that Ann must also be *in* the School of Education.

Table 1
The Four Basic Laws of Logical Inference

Excluded middle	Every element *X* is either a member of class *A* or not a member of class *A*.
Modus ponens	Given classes *A* and *B* and an element *X*, if *A* is a subclass of *B* and *X* is a member of *A*, then *X* is a member of *B*.
Hypothetical syllogism	Given three classes *A*, *B*, and *C*, if *A* is a subclass of *B* and *B* is a subclass of *C*, then *A* is a subclass of *C*.
Modus tollens	Given classes *A* and *B* and an element *Y*, if *A* is a subclass of *B* and *Y* is not a member of *B*, then *Y* is not a member of *A*.

Inquiry Methods and the Making of Meaning

One of the central issues in embodiment theory is the need for representations, such as propositions and diagrams, to be meaningful in order to be accepted by agents who may listen to or view them. Glenberg (1997) argues that our ability to discriminate between meaningful and nonsensical statements stems from our natural evaluation of the affordances of the entities in question. Affordances (Gibson, 1979) are the potential ways that we naturally interact with objects and the environment. When we evaluate statements such as *After wading barefoot in the lake, Erik used his [shirt / glasses] to dry his feet* as meaningful or nonsensical, we are considering the affordances of the objects referred to in the sentences and considering (through a process of *envisionment*) the plausibility that they combine, or *mesh*, in a coherent manner.

Glenberg (1997) argues that our understanding of statements is mediated by our ability to index (or map) words and phrases to objects in the world, or to analogical representations of objects such as pictures, inscriptions, or perceptual symbols (Barsalou, 1999). Glenberg's *indexical hypothesis* states that, in the attempt to make meaning, we first index words to objects (or their analogical representations); next, we derive affordances from the objects (or their analogical representations); and finally, we assess meaning from the combination of affordances, rather than from the combination of the words themselves. Evidence from a number of studies examining readers' understanding of statements about orienteering (Glenberg & Robertson, 1999) and narratives about farms (Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, 2004) supports the hypothesis that the ability to index words to objects greatly facilitates comprehension. When readers cannot index the words to the physical entities, they may still exhibit simple recall, but they do poorly on tasks that require them to use the objects being referred to (Glenberg & Robertson, 1999).

Meaning making is an essential element of inquiry, and ultimately one of the most significant criteria upon which we evaluate whether we are doing productive research in education and the learning sciences. The meaning of the actions and products of our inquiry must be continually assessed during inquiry in order to monitor its validity. It is likely to be insufficient to rely solely on the syntactic properties of operations to achieve meaningful results in all but the simplest areas of inquiry. That assessment of meaningfulness, as argued by Glenberg and Robertson and by Lakoff, Johnson, and Núñez, comes from our embodied

experience. As Núñez (2000) reflected, "The truths of these traditional [Boolean] laws of logic are thus not dogmatic. They are true by virtue of what they mean" (pp. 12–13).

Implications for Coding: Categories and Classes in Qualitative Research

By building on these ideas about Boolean logic, we hypothesize that the process of coding data is inherently a way of collecting and containing data, and is commonly found in seminal studies and qualitative methods handbooks. To investigate this hypothesis, we sampled from some of the most frequently cited authors in the arena of qualitative coding to examine the ways in which they describe (and often instruct) the process of coding. To begin, we have Glaser and Strauss's (1967) *constant comparative method*, in which the unit of comparison changes from (a) looking at incidents in relation to each other to (b) looking at an incident and then comparing that with the properties that emerged from the initial comparison of incidents. For example, Glaser and Strauss compare the responses of nurses to a patient who dies. The category of *social loss* emerges from a comparison of comments such as, "He was to be a doctor" and "What will her husband and the children do without her?" As the authors note (p. 206), the "theoretical properties of a category" are generated fairly quickly through this comparison of incidents to each other and to the other evolving categories.

In Spradley's (1979) *domain analysis*, any symbolic category, such as *tree*, can include other (sub-)categories, such as *oak*, *pine*, and *aspen*. Spradley claims that domains are the first and most important unit of analysis in ethnographic and psychological (e.g., Varela, Thompson, & Rosch, 1991) research and that the discovery of these categories and sub-categories allows for an understanding of cultural knowledge from the perspective of various social actors. Every domain has a *boundary*, which allows us to ascertain inclusion or exclusion (e.g., "no, this isn't a tree, it's a bush"). Finally, far from being a pedantic, simplistic approach, identifying and analyzing what Spradley calls *folk domains* is one of the most difficult tasks faced by ethnographers. Spradley's proposal of *universal semantic relationships* (p. 111) is also intriguing for its parallels with BCs (Table 2). These semantic relationships all require the notion of container schemas as the basic building blocks for coming to understand the worldview of a cultural actor in the context of larger, socially produced patterns.

Table 2
Spradley's (1979, p. 111) Universal Semantic Relationships

Strict inclusion	*X* is a kind of *Y*
Spatial	*X* is a place in *Y*, *X* is a part of *Y*
Cause-effect	*X* is a result of *Y*, *X* is a cause of *Y*
Rationale	*X* is a reason for doing *Y*
Location for action	*X* is a place for doing *Y*
Function	*X* is used for *Y*
Means-end	*X* is a way to do *Y*
Sequence	*X* is a step (stage) in *Y*
Attribution	*X* is an attribute (characteristic) of *Y*

Finally, LeCompte and Schensul (1999) specifically discuss coding as devising a name or symbol to represent a group of similar terms, ideas, or phenomena. LeCompte and Schensul see a connection between thoughtful, systematic coding and the kind of thinking people do in everyday life through the processes of perceiving, comparing, contrasting, aggregating, ordering, establishing linkages/relationships, and speculating. Codes stand for groups of terms or phenomena noticed by the researcher. In order to gain clarity on the frequency and meaning of these terms or phenomena, researchers engage in coding. All of this relies on the classification of data into groups with at least some differing properties. In addressing the processes of handling data, none of these scholars claims that coding is the culmination of the research process or that it should dominate the research process. Furthermore, they each present different ways of orchestrating the research process. However, they do imply that coding and comparing codes/categories are essential parts of qualitative methodology.

Implications for Bridging Qualitative and Quantitative Methods

Our interest in qualitative research, Boolean logic, and QDAS stems, in part, from claims such as Lonkila's (1995) that the positivistic orientation of software packages is somehow antithetical to qualitative research and more akin to quantitative research. Recent literature on mixed methods (Creswell, 2003) has helped break through the boundaries of qualitative and quantitative approaches to demonstrate that they may be combined in many different ways and for many different reasons. Yet, some debates in education research still emphasize the ways in which qualitative and quantitative research differ. Recent debates such as those regarding scientific research in education demonstrate that the perception of these boundaries is quite real, and loaded with political implications.

However, this debate also serves as one of the vehicles through which we are engaging in new discussions of research that explore (and expose!) the potentially tenuous boundaries between qualitative and quantitative research. Dohan and Sanchez-Jankowski (1998) noted that the terms *quantitative* and *qualitative* are often misunderstood, because they refer to differences in epistemologies, and not to the use of data per se. If we are to better understand these epistemologies, we must reexamine our categories of and within research. For instance, some researchers become entrenched in the notion that Boolean logic is somehow more quantitative than qualitative.

One common understanding of qualitative data is that codes may be modified as the research progresses and as the investigator's additional reflections present new ways of understanding the data. In quantitative research, however, we often assume that codes, once chosen, must not be changed. Rather than simply subscribe to these rules, we would be more prudent, as Dohan and Sanchez-Jankowski (1998) imply, to focus less on the type of data and more on the research questions and assumptions. By doing so, we can then ask "why?" or "why not?" regarding the static or dynamic status of a code, regardless of whether we are examining a qualitative or quantitative piece of data. A careful and productive look at our own socially defined categories of quantitative and qualitative research might be achieved by an extension of the process used here to understand how we use containers and metaphors to make sense of our world and to build conceptual frameworks.

References

Arnheim, R. (1974). *Art and visual perception: A psychology of the creative eye*. Berkeley: University of California Press.

Barry, C. A. (1998). Choosing qualitative data analysis software: Atlas/ti and NUD*IST compared. *Sociological Research Online, 3*(3). Retrieved March 14, 2006, from http://www.socresonline.org.uk/3/3/4.html

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*(4), 577–660.

Bowdle, B., & Gentner, D. (2005). The career of metaphor. *Psychological Review*, *112*(1), 193–216.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. (1956). *A study of thinking*. New York: Wiley.

Clark, A. (1999). An embodied cognitive science? *Trends in Cognitive Science 3*(9), 345–351.

Coffey, A., Holbrook, B., & Atkinson, P. (1996). Qualitative data analysis: Technologies and representations. *Sociological Research Online*, *1*(1). Retrieved March 14, 2006, from http://www.socresonline.org.uk/1/1/4.html#top

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches.* Thousand Oaks, CA: Sage.

Creswell, J. W, & Maietta, R. C. (2002). Qualitative research. In D. Miller & N. J. Salkind (Eds.), *Handbook of research design and social measurement* (pp. 143–197). Thousand Oaks, CA: Sage.

DeVega, M., Glenberg, A, M. & Graesser, A. C. (in press). *Symbols, Embodiment and Meaning: A Debate*. Oxford: Oxford University Press.

Dohan, D., & Sanchez-Jankowski, M. (1998). Using computers to analyze ethnographic field data: Theoretical and practical considerations. *Annual Review of Sociology, 24*, 477–498

Dreyfus, H. (1992). *What computers still can't do*. Cambridge, MA: MIT Press.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin

Glaser B., & Strauss, A. (1967). *The discovery of grounded theory.* Chicago: Aldine.

Glenberg, A. (1997). What memory is for. *Behavioral and Brain Sciences, 20*(1), 1–55.

Glenberg, A. M., Gutierrez, T., Levin, J. R., Japuntich, S., & Kaschak, M. P. (2004). Activity and imagined activity can enhance young children's reading comprehension. *Journal of Educational Psychology, 96*, 424–436.

Glenberg, A. M., & Robertson, D. A. (1999). Indexical understanding of instructions. *Discourse Processes, 28,* 1–26.

Heidegger, M. (1962). *Being and time* (J. Macquarrie & E. Robinson, Trans.). New York: Harper. (Original work published 1927)

Hubel, D. H., & Wiesel, T. N. (1968). Receptive fields and functional architecture of monkey striate cortex. *Journal of Physiology, 195*, 215–243.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to western thought.* New York: Basic Books.

Lakoff, G., & Núñez, R. E. (2000). *Where mathematics comes from*. New York: Basic Books.

LeCompte, M. D., & Schensul, J. J. (1999). *Analyzing and interpreting ethnographic data* (Ethnographer's toolkit; Vol. 5). Walnut Creek, CA: AltaMira Press.

Lee, R. M., & Fielding, N. (1996). Data analysis: Representations of a technology: A comment on Coffey, Holbrook and Atkinson. *Sociological Research Online, 1*(4). Retrieved April 28, 2006, from http://www.socresonline.org.uk/1/4/lf.html

Lonkila, M. (1995). Grounded theory as an emerging paradigm for computer-assisted qualitative data analysis. In U. Kelle (Ed.), *Computer-aided qualitative data analysis* (pp. 41–51). London: Sage.

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought.* Chicago: Chicago University Press.

Merleau-Ponty, M. (1962). *Phenomenology of perception* (Colin Smith, Trans.). London: Routledge. (Original work published 1945)

Núñez, R. E. (2000). Mathematical ideas analysis: What embodied cognitive science can say about the human nature of mathematics. *Proceedings of PME, 24*(1), 3–22.

Roberts, K. A., & Wilson, R. W. (2002, May). ICT and the research process: Issues around the compatibility of technology with qualitative data analysis. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 3*(2). Retrieved March 14, 2006, from http://www.qualitative-research.net/fqs-texte/2-02/2-02robertswilson-e.htm

Schwandt, T. A. (2001). *Dictionary of qualitative inquiry*. Thousand Oaks, CA: Sage.

Spradley, J. A. (1979). *The ethnographic interview.* New York: Holt, Rinehart & Winston.

Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind: Cognitive science and human experience*. Cambridge, MA: MIT Press.